A Remedy for a Chronic Dredging Problem

By Mr. David C. Gordon

The US Army Corps of Engineers (USACE) recently constructed a set of innovative river training structures in the Upper Mississippi River to remedy a repetitive maintenance-dredging problem. Due to the complexity of this reach of river, the problem required the development of a unique solution to meet the objectives of numerous user groups and agencies involved.

The reach of river, called Bolters Bar, is located about 45 river miles upstream of St. Louis, Missouri (just upstream of the confluence with the Illinois River). It is used heavily by commercial navigation tows and is part of a crucial link between the Upper and Lower Mississippi Rivers. At this location, the river is divided into as many as four separate channels, with one of the densest concentrations of marinas and recreational boats along the entire Mississippi River. In the summer months, thousands of recreational boaters regularly use these channels.

USACE is responsible for maintaining a navigable channel at least 9 feet deep by 300 feet wide on the Upper Mississippi River, through the use of river training structures, dredging operations, and water-level management at the locks and dams. This reach of river had required dredging—usually once or twice a year—due to depths that did not meet the minimum requirements. In most years, dredging was needed during the fall harvest—the busiest period for shipping agricultural products down the Mississippi River for export. During crucial shipping periods, groundings could close the river down for days for cleanup.

In terms of dredging frequency, this reach has been one of the most troublesome on the Upper Mississippi River. Within this 1-mile reach, more than 5.5 million cubic yards of river sediment have been dredged at a cost of over $6.1 million. The most recent dredging operation to reopen this channel in 2001 took 12 days to remove more than 300,000 cubic yards of sediment at a cost of almost $500,000. Locating viable dredge

Innovative river training structures remedied a chronic dredging problem and created unique aquatic habitat.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **DEC 2004**	2. REPORT TYPE	3. DATES COVERED **00-00-2004 to 00-00-2004**

4. TITLE AND SUBTITLE **A Remedy for a Chronic Dredging Problem**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Engineer School,14010 MSCoE Loop BLDG 3201, Suite 2661,Fort Leonard Wood ,MO,65473-8702**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

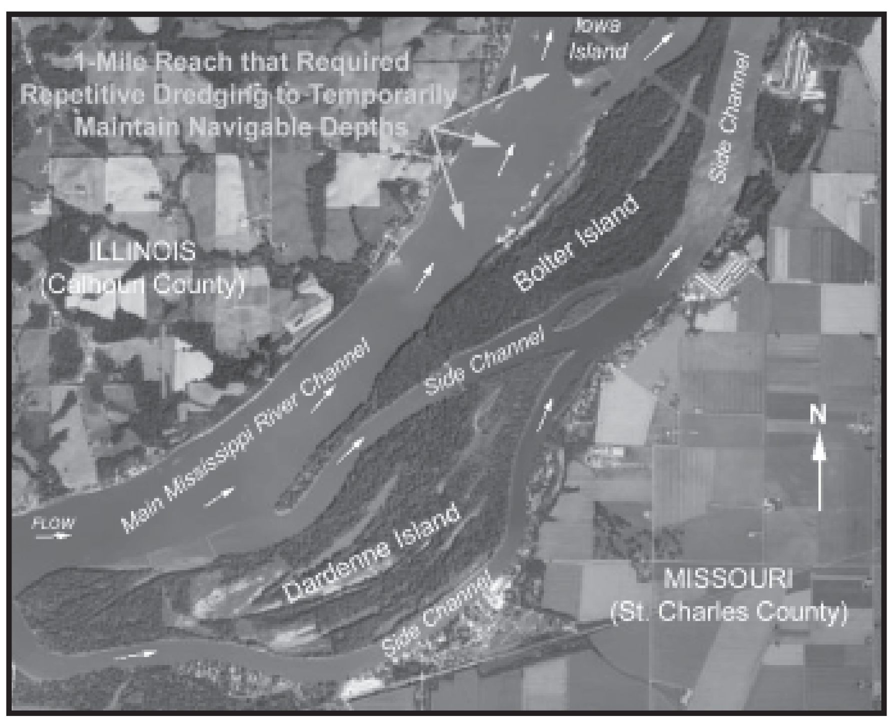
Bolters Bar project location map

disposal areas that would not negatively impact recreation, homeowners, or the environment has also proved problematic.

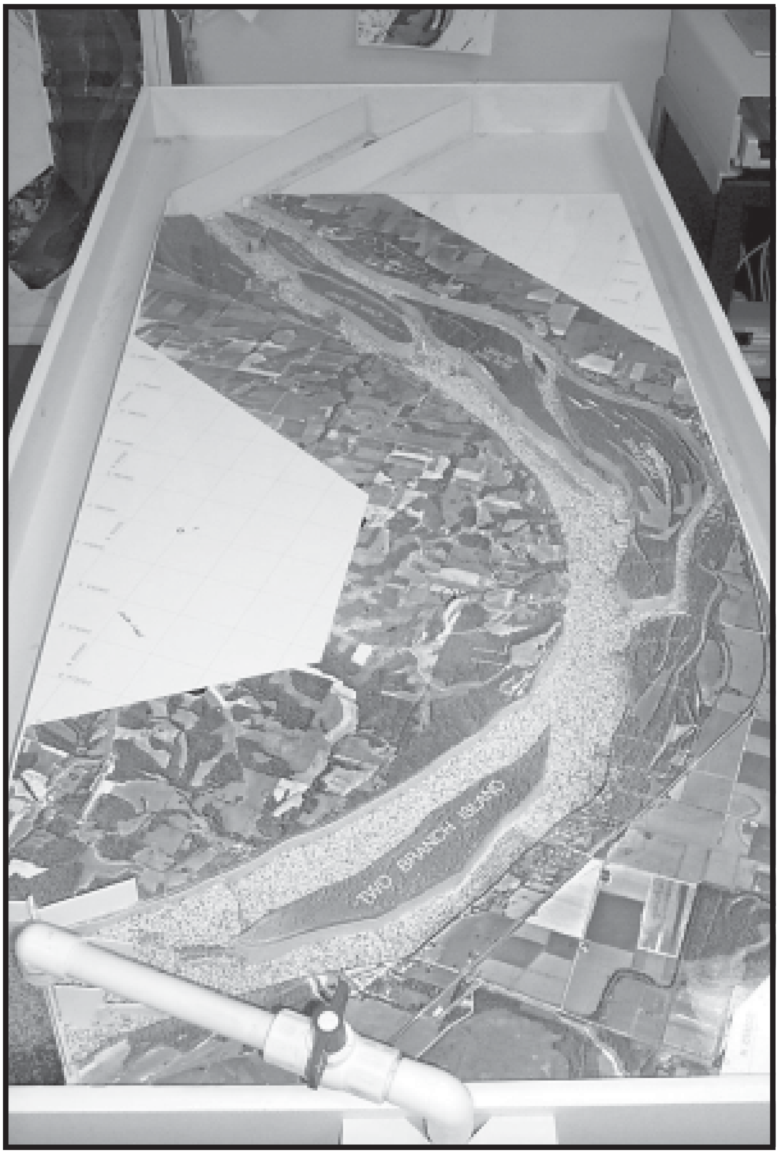
One cause of repetitive dredging through the reach was the loss of flow in the main channel to the side channels. Measurements of flow distribution show that, at times, the main channel carries less than 50 percent of the total flow in the river while the majority of water flows through the side channels.

A conventional solution to the problems would have been to construct rock closure structures across the mouths of each of the side channels. This measure would have distributed additional flow in the main channel at the expense of the side channels. However, closing off the side channels would have adversely affected the environment of the river and recreational boaters. Therefore, USACE needed a way to evaluate unconventional designs that would reduce the repetitive-channel, maintenance-dredging situation without damaging the environment or creating problems for recreational boaters. Assessments of needed alternatives included examination of the ultimate effects to sedimentation patterns within the main channel, at the entrances to the side channels, and within each side channel.

To accomplish assessments of multiple designs, a small-scale, physical, hydraulic, movable riverbed model was used. This micro model not only allowed engineers to test numerous design alternatives in a detailed manner but also allowed for the involvement of the USACE partners during the design conception phase. One of the advantages of a physical model is the interaction it provides for customers and partners. Complex river concepts can be visually observed and understood by



Area requiring repetitive dredging



Bolters Bar Micro Model

nonengineers, which creates a team-building experience with all interested parties. This process ensures that all those involved in the project agree on the final design.

USACE uses micro modeling technology for both plan formulation and final design parameters. These physical, hydraulic models of a river or stream use small-scale and movable riverbeds. The modelers use empirical techniques to replicate the trends of the riverbed to study sediment distribution and riverbed pattern development within a river channel. This includes the general location of sandbars, the depositional areas, the scour holes, and the channel thalweg (the line of the deepest water in the river channel). The modeling then allows for the estimated prediction of riverbed patterns when applying a structure in the river channel.

The model used to study the Bolters Bar reach was developed at the USACE Applied River Engineering Center, St. Louis, Missouri. The model—which incorporated almost 11 miles of the main river channel, as well as each side channel and every river training structure—was only 6 feet long and 3 feet wide. The bed material used to simulate the riverbed of the Mississippi was a granular plastic.

Surveys of the river bottom were used to calibrate this model. The plan formulation team then used the model to idealize numerous design possibilities for consideration by the design team. These concepts were later scientifically tested in the model to determine their probable effect on the riverbed. Results of these tests were then presented to the plan formulation team for evaluation.

The micro model showed that numerous designs using traditional river engineering concepts would greatly reduce dredging. Standard dike fields placed along both banks would direct the river flow into the center of the channel, thereby increasing depths. However, the means of solving traditional dredging issues with standard engineering practices were not acceptable to the environmental agencies and recreational interests. Therefore, combinations of dikes and chevron structures that would also address environmental concerns were evaluated in the model. Chevrons are large U-shaped rock structures with blunt noses and open ends that face downstream.

Most of the designs tested in the model showed that probable improvements to dredging could be gained from each combination of structure. However, the designs were also evaluated on their effects within each side channel, the alignment for navigation, and the capacity to create additional aquatic habitat. These parameters were then weighed with the costs associated with each design to determine the most economical solution.

The team agreed on an unconventional design that addressed the needs and concerns of everyone involved. The design consists of a unique longitudinal dike and four chevron structures. The 1,200-foot-long longitudinal dike extends off of Bolter Island and is angled downstream in a nearly parallel alignment to the flow of the river. Downstream of this structure are four chevrons about 850 feet apart and built of graded 5,000-pound, maximum-size stone. The chevrons are

USACE biologists collect fisheries data around a chevron at Bolters Bar

about 250 feet long, 200 feet wide between the downstream ends of the legs, and 600 feet in total length along the perimeter of the structure. The project was completed in 2002 at a cost of nearly $1.5 million for about 160,000 tons of stone.

Although the structures have only been in the river for two years, the results have been outstanding because the reach has not required dredging. After the project was completed, surveys showed that the minimum depth and width required for navigation had been created by the structure's interaction with the river and its sediment. Areas that used to be less than 10 feet deep are now at least 15 feet. In addition, the navigation channel is now wide enough that, on occasion, tows have been able to overtake one another without incident. Monitoring of the side channel immediately downstream of the structures shows that shoaling has not occurred, and depths have been maintained, just as the micro model suggested. The surveys of the river suggest that the micro model accurately predicted the effect that the design has on the trends of the riverbed. As an engineering tool for the prediction of bathymetry trends in a continually changing river environment, the predictive accuracy displayed by this model was at an exceptional level.

Although biological monitoring can take years to assess, the results from similar chevrons give a valid representation of what could be expected to occur in and around these structures. Six other chevrons built in the 1990s have been extensively monitored for their biological effects. More than 50 species of fish and a highly diverse group of macroinvertebrates have been collected in and around the structures. Physical data has shown that these structures have created several different types of river habitat with variable depths, flow velocities, and substrates and multiple wetted edges where plant life can flourish. It has been documented that this environment is very conducive to the needs of overwintering fish and provides ideal conditions for a nursery for juvenile and larval fish. Plant life that establishes itself along the wetted edges provides good cover and habitat for young fish. The chevrons built in the Bolters Bar reach are expected to result in the same diverse group of habitat types and species benefits.

This unconventional solution to a troublesome problem has the potential to save millions of dollars in dredging costs. It is estimated that this project will pay for itself after just three years. Although the total cost of the project was $1.5 million, $500,000 was spent in one year of dredging in 2001. Additionally, there are monetary values that result from increased safety and the reduced risk of accidents or groundings. The navigation industry as a whole incurs significant costs from events such as those that close the river to traffic for any amount of time. The environmental benefits have also been immense, but they are difficult to quantify. The project provides a mosaic of aquatic habitat not readily found along the river, such as deep slack water, off-channel nursery areas, and aquatic vegetation.

Since construction, tow pilots have not encountered any navigation problems and have been pleased with

the results of channel improvements. And once recreational boaters became familiar with the location of the new structures in the river, they did not express any concern over the project.

This project demonstrated that it is possible to remedy a difficult navigation problem in an area where multiple user groups had a strong desire to protect their own interests. The use of the micro model allowed engineers, biologists, tow pilots, and environmentalists the unique opportunity to work together to experiment with and design nontraditional river engineering solutions that may not have been considered with other design techniques. The results of this novel project have shown that it is possible to achieve a "win-win" scenario between navigation interests and the environment.

Mr. Gordon is a senior river engineer for the St. Louis District Corps of Engineers at the Applied River Engineering Center (AREC). He assists in leading a staff of engineers and technicians who perform micro model studies of the Mississippi, Missouri, Kaskaskia, Illinois, and Atchafalaya Rivers. He has been the primary designer of many river engineering design measures that have solved a number of problems, including repetitive-maintenance dredging. He has authored several technical papers and has made presentations at sedimentation conferences. In 2004, Mr. Gordon received the International Navigation Association's De-Paepe Willems award for the US Section. He recently visited Uzbekistan to design port facilities for the Uzbek Border Patrol unit.